Sub B2 concl'd
B6 concl'd



67. (New) The method according to claim 40 wher in the $M^{III}N$ layer has a thickness of approximately 0.01 micron or greater.

## REMARKS

### *Status of the Application*

In the present application, originally-filed claims 1 – 56 are pending. Claims 48-56 are withdrawn from consideration as being directed to non-elected subject matter. Accordingly, claims 1 – 47 have been substantively examined and are the subject of the present amendment, as well as new claims 57 – 67 discussed herein.

In the above-referenced Office Action dated December 18, 2002, claims 40-47 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,686,738 to Moustakas (hereinafter "Moustakas"). Claims 1 – 17 and 19-39 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Moustakas in view of U.S. Patent No. 4,491,560 to Fujii et al. (hereinafter "Fujii et al"). Claim 18 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

In the present Amendment, applicants have cancelled claims 15 and 25 - 31, and have amended claims 1, 18 – 24, 32, 33, 37 – 40 and 44. In addition, applicants have added new claims 57 – 67.

### *Claim Rejections - 35 U.S.C. § 102*

The Examiner rejects claims 40 – 47 under 35 U.S.C. § 102(b) as being anticipated by Moustakas. Applicants respectfully traverse this rejection because Moustakas fails to teach each and every limitation recited by the rejected claims.

Independent claim 40 is directed to a "method for producing a single-crystal $M^{III}N$ article". One of the steps of claim 40 recites "using a sputtering

apparatus comprising a non-thermionic electron/plasma injector assembly to produce a Group III metal source vapor from a Group III metal target." Moustakas fails to teach the use of a sputtering apparatus in any form to produce a Group III metal source vapor from a Group III metal target. Moustakas teaches the growth of gallium nitride by using a conventional molecular beam epitaxy (MBE) system. It is well known that MBE is an evaporation technique and thus is a type of thermal process while, by contrast, sputtering is a non-thermal process. In the MBE process, gallium metal is heated to high temperature (1000°C or thereabouts) in an effusion cell in a high vacuum environment. Under these conditions, gallium evaporates to form a metal vapor and is then transported to a substrate in a growth chamber by opening a shutter between the effusion cell and the growth chamber. To provide a source of activated nitrogen, Moustakas integrates an electron cyclotron resonance (ECR) microwave plasma device with the MBE apparatus. The ECR device ionizes nitrogen for reaction with the gallium to form gallium nitride. The ECR creates a plasma in its high-vacuum plasma chamber, and the resulting ions are then directed into the growth chamber through an effusion port.

In contrast to evaporation processes such as the MBE process taught by Moustakas, sputtering processes use ion bombardment as a mechanism to physically eject atoms/molecules from a solid target. The ejected atoms/molecules are then transported to the substrate. A plasma is utilized in the invention of claim 40 to provide energy for the sputtering system and to transport the resulting metal vapor to the substrate. Moustakas at col. 4, lines 11 – 12, mentions "sputter-etching" the substrate by using the nitrogen plasma prior to film growth. Plasma etching, however, is merely a conventional, pre-growth substrate cleaning or preparation step that does not relate to the creation of a metal vapor that is to be transported to the substrate. Moustakas fails to teach a metal target from which sputtered particles are obtained.

While ECR can be considered to be a non-thermionic process, it is used by Moustakas only to create the activated nitrogen sp cies for subsequent reaction with evaporated gallium metal. Moustakas teaches producing gallium vapor by means of evaporation in a conventional effusion cell to provide a molecular beam source of gallium. The ECR process has no influence on the way the gallium vapor is produced. In contrast, the non-thermionic sputtering process of the present invention is used to increase the flux of the gallium vapor to enable higher growth rates, and not for creating the nitrogen species. Moreover, in the "Summary of the Invention" section of his specification, Moustakas teaches that a "hot tungsten filament" could also be used to provide the activated nitrogen species. The use of a hot tungsten filament is well known to be a thermionic process (electrons are thermionically emitted from the filament due to its high temperature), in direct contrast to the teaching of the present application with respect to claim 40.

Dependent claims 41 and 42 are directed to the injector assembly used in independent claim 40. The injector assembly disclosed and claimed in the present application is a unique feature of the present invention and is not taught in any form by the prior art.

Dependent claim 43 requires "the step of removing the template material." As stated by the Examiner on page 3 of the Office Action, Moustakas fails to teach the step of removing the template material.

Claims 44 – 47 are directed to a single-crystal $M^{III}N$ article produced according to the sputtering method of claim 40. Claims 44 – 47 require the single-crystal article to be produced at either dimensions or growth rates not heretofore possible, prior to the present invention. With respect to claims 44 – 46, Moustakas reports the growth of a gallium nitride thin film having a thickness of only 1 micron (column 4, lines 27 – 28) and teaches a preferred thickness in the thin-film range of 0.5 to 10 microns (column 2, lines 46 – 47). With respect to claim 47, Moustakas fails to teach growth rates.

In view of the foregoing, applicants resp ctfully submit that claims 40 – 47 are patentable over Moustakas under 35 U.S.C. § 102(b), and respectfully request the Examiner to withdraw the rejection to claims 40 – 47.

*Claim Rejections - 35 U.S.C. § 103*

Claims 1 – 17 and 19 – 39 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Moustakas in view of Fujii et al. The Examiner states that Moustakas fails to teach the step of removing the template material, but that Fujii et al. teaches the step of removing the template material such that it would have been obvious to apply the teachings of Fujii et al. into the method of Moustakas. Applicants respectfully traverse this rejection because Moustakas and Fujii et al in combination fail to teach, suggest, or provide motivation for the invention as defined in the rejected claims.

Fujii et al teaches a process for producing large crystal grains or a single crystal of molybdenum by annealing polycrystalline molybdenum powder, mixed with calcium and magnesium, at high temperatures. The process is not a material deposition or growth process, and the resulting molybdenum material is not separated from a template material. Accordingly, applicants submit that Fujii et al do not teach or suggest the removal step recited in claim 1, and further that the disclosure by Fujii et al is not relevant to applicants' invention as recited in the rejected claims.

Claim 1 is directed to a "method for producing a single-crystal $M^{III}N$ article". Claim 1 recites the step of "sputtering a Group III metal target in a plasma-enhanced environment to produce a Group III metal source vapor". As discussed hereinabove, Moustakas fails to teach sputtering in any form to produce a Group III metal source vapor from a Group III metal target. The addition of the teaching of Fujii et al. fails to cure the deficiencies of Moustakas with respect to claim 1 as well as all other rejected claims.

Claims 2 – 14 depend from claim 1, and therefore are distinguishable for the same reasons.

Claim 15 has been cancelled, rendering the rejection to claim 15 moot.

Claim 16 depends from claim 1, and therefore is distinguishabl for the same reasons.

Claim 17 recites that "the $M^{III}N$ layer is formed at a growth rate of approximately 10 microns/hour or greater." This growth rate is neither taught nor suggested by the cited references.

Claims 19 – 24 have been amended so as to now depend from new claim 59. New claim 59 recites "the steps of continuing to deposit the reactant vapor species on the growth surface and removing the template material to provide a free-standing, single-crystal $M^{III}N$ article." As discussed hereinabove, Moustakas and Fujii et al. fail to teach or suggest the removal of template material. With regard to claim 19, it is believed that, prior to the present invention, it has not been possible to produce an $M^{III}N$ article having a thickness of approximately 1 mm or greater by sputtering methods.

Claims 25 – 31 have been cancelled, thereby rendering their rejection moot.

Claims 32 and 33 have been amended so as to now depend from new claim 62, such that claims 32 – 36 all now ultimately depend from new claim 62. New claim 62 is directed to a "method for producing a single-crystal $M^{III}N$ article." New claim 62 requires the step of "sputtering a Group III metal target in a plasma-enhanced environment to produce a Group III metal source vapor." As discussed hereinabove, Moustakas and Fujii et al. fail to teach or suggest this step. New claim 62 further requires the step of "using the single-crystal $M^{III}N$ layer as a seed crystal and depositing additional reactant vapor species comprising the Group III metal and nitrogen on the $M^{III}N$ to produce a bulk, homoepitaxially grown $M^{III}N$ article." The growth of a bulk $M^{III}N$ article on a single-crystal seed is not in any manner taught or suggested by Moustakas and Fujii et al. Claims 32 – 36, which ultimately depend from new claim 62, are therefore distinguishable for the same reasons.

Claims 37 – 39 are directed to a "single-crystal $M^{III}N$ article produced according to the method of claim 1." Claims 37 – 39 now depend from new claim 59. Claims 37 – 39 require the single-crystal article to be produced at dimensions not heretofore possible, prior to the present invention.

In view of the foregoing, applicants respectfully submit that claims 1 – 17 and 19 – 39 are patentable over the combined disclosures of Moustakas and Fujii et al under 35 U.S.C. § 103(a), and respectfully request the Examiner to withdraw the rejection to claims 1 – 17 and 19 – 39.

## *New Claims*

New claims 57 – 67 have been added. New claims 57 – 67 are fully supported by the application as originally filed, and thus no new matter has been added.

New claims 57 – 61 all ultimately depend from claim 1, and therefore are distinguishable over the prior art for the same reasons.

New claim 62 is an independent method claim, the patentability of which is discussed hereinabove.

New claims 63 – 65 depend from new claim 62, and therefore are patentable for the same reasons.

New claims 66 and 67 depend from independent claim 40, and are distinguishable over the prior art for the same reasons.

## *Other Claim Amendments*

Claim 40 has been amended herein to correct a typographical error, and thus not for any purpose relating to patentability. Other minor claim amendments, such as changes in claim dependency, have been discussed hereinabove.

Serial No.: 09/998,080

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Pursuant to 37 C.F.R. § 1.121, attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

CONCLUSION

In light of the above amendments and remarks, it is respectfully submitted that the present application is now in proper condition for allowance, and such action is earnestly solicited.

If any small matter should remain outstanding after the Patent Examiner has had an opportunity to review the above Remarks, the Patent Examiner is respectfully requested to telephone the undersigned patent attorney in order to resolve these matters and avoid the issuance of another Official Action.

DEPOSIT ACCOUNT

The Commissioner is hereby authorized to charge any fees associated with the filing of this correspondence to Deposit Account No. **50-0426**.

Respectfully submitted,

JENKINS & WILSON, P.A.

Date: March 18, 2003 By: David P. Gloekler

David P. Gloekler
Registration No. 41,037

Suite 1400 University Tower
3100 Tower Boulevard
Durham, North Carolina 27707
Telephone: (919) 493-8000
Facsimile: (919) 419-0383

297/105/2 REJ/DPG/cht

Customer No. Bar Code Label: 25297
Patent Trademark Office

## VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

On page 6, the paragraph at lines 13 – 22 has been amended as follows:

According to one method of the present invention, a single-crystal $M^{III}N$ article is produced. A template material having an epitaxial-initiating growth surface is provided. A Group III metal target is sputtered in a plasma-enhanced environment to produce a Group III metal source vapor. The Group III metal source vapor is combined with a nitrogen-containing gas to produce reactant vapor species comprising the Group III metal and nitrogen. The reactant vapor species is deposited on the growth surface to produce a single-crystal $M^{III}N$ layer thereon. In one aspect, the single-crystal $M^{III}N$ layer is grown as a thin film, i.e., with a thickness of approximately 10 to 10,000 mn (.01 to 10 microns), for use as a seed crystal upon which a bulk, second $M^{III}N$ layer can be grown. In another aspect, growth of the $M^{III}N$ layer is permitted to continue beyond the thin film range until its thickness is sufficient to ensure that the resulting bulk crystal has a low enough defect density to be considered as device-quality. In a further aspect, the $M^{III}N$ layer is grown to a bulk thickness and the [The] template material is removed, thereby providing a free-standing, single-crystal $M^{III}N$ article having a diameter of approximately 0.5 inch or greater and a thickness of approximately 50 microns or greater.

IN THE CLAIMS:

Claims 15 and 25 – 31 have been cancelled.

Claims 1,19 – 24, 32, 33, 37 – 40 and 44 have been amended as follows:

1. (Amended) A method for producing a single-crystal $M^{III}N$ article comprising the steps of:

   (a) providing a template material having an epitaxial-initiating growth surface;

   (b) sputtering a Group III metal target in a plasma-enhanced environment to produce a Group III metal source vapor;

(c) combining th Group III m tal source vapor with a nitrogen-containing gas to produce a reactant vapor species comprising Group III metal and nitrogen; and

(d) depositing the reactant vapor species on the growth surface to produce a single-crystal $M^{III}N$ layer thereon having a thickness of greater than approximately 10 microns[; and

(e) removing the template material, thereby providing a free-standing, single-crystal $M^{III}N$ article having a diameter of approximately 0.5 inch or greater and a thickness of approximately 50 microns or greater].

18. (Amended) The method according to claim 59 [1] wherein the $M^{III}N$ article is provided in a form selected from the group consisting of intrinsic $M^{III}N$, doped $M^{III}N$, and $M^{III}N$ alloys and compounds containing greater than 50% $M^{III}$ and N.

19. (Amended) The method according to claim 59 [1] wherein the $M^{III}N$ article has a diameter of approximately 2 inches or greater and a thickness of approximately 1 mm or greater.

20. (Amended) The method according to claim 59 [1] wherein the template material is removed by a removal technique selected from the group consisting of polishing, chemomechanical polishing, laser-induced liftoff, cleaving, wet etching, and dry etching.

21. (Amended) The method according to claim 59 [1] comprising the step of cutting a wafer from the $M^{III}N$ article.

22. (Amended) The method according to claim 59 [1] comprising the step of preparing a surface of the $M^{III}N$ article for epitaxial growth thereon.

23. (Amended) The method according to claim 59 [1] comprising the step of depositing an epitaxial layer on the $M^{III}N$ article.

24. (Amended) The method according to claim 59 [1] comprising the step of forming a device on the $M^{III}N$ article.

32. (Amended) The method according to claim 62 [31] wherein the additional reactant species are [bulk $M^{III}N$ article is] deposited by a technique selected from the group consisting of physical vapor deposition, sputtering, molecular beam epitaxy, atmospheric chemical vapor deposition, low pressure chemical vapor deposition, plasma-enhanced chemical vapor deposition, metallorganic chemical vapor deposition, evaporation, sublimation, and hydride vapor phase epitaxy.

33. (Amended) The method according to claim 62 [31] comprising the step of cutting a wafer from the bulk $M^{III}N$ article.

37. (Amended) A bulk single-crystal $M^{III}N$ article produced according to the method of claim 59 [1] wherein the article has [a diameter of approximately 0.5 inch to approximately 12 inches and] a thickness of approximately 50 microns or greater.

38. (Amended) A single-crystal $M^{III}N$ article produced according to the method of claim 59 [1], wherein the article is in wafer form having a thickness ranging from approximately 50 microns to approximately 1 mm.

39. (Amended) A single-crystal $M^{III}N$ article produced according to the method of claim 59 [1], wherein the article is in boule form having a

diameter of approximately 2 inches or greater and a thickness ranging from approximately 1 mm to greater than approximately 100 mm.

40. (Amended) A method for producing a single-crystal $M^{III}N$ article comprising the steps of:

(a) providing a template material having an epitaxial-initiating growth surface;

(b) using a sputtering apparatus comprising a non-thermionic electron/plasma injector assembly to produce a Group III metal source vapor from a Group III metal target;

(c) combining the Group III metal source vapor with a nitrogen-containing gas to produce a reactant vapor species comprising Group III metal and nitrogen; and

(d) depositing the reactant vapor species on the growth surface to produce <u>a</u> [an] single-crystal $M^{III}N$ layer thereon.

44. (Amended) A bulk single-crystal $M^{III}N$ article produced according to the method of claim 40 wherein the article has [a diameter of approximately 0.5 inch or greater and] a thickness of approximately 50 microns or greater.